Space Weather Technical Forecast

Issued on Tuesday, 25 July 2023 at 13:22 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance R1/R2 blackouts throughout. Chance of G1 Minor geomagnetic storms later day 2 into day 3 (26/27 Jul).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate over the past 24 hours with a long period M1.5 flare observed from AR3376 peaking at 25/0203 UTC. A3376 remains currently the most active region on the disc, with ongoing slight growth in surrounding spots, and an east-west component to the polarity separation line suggesting increased potential instability. AR3380 is the other region of notable recent growth though signs of a weak delta spot visible ahead of the main spot have faded. This area continues to be split into two regions, with a smaller as yet unnumbered bipolar region following. The large AR3379 has also been split into three regions, including AR3382 and AR3383. AR3373 has seen a more rapid decrease to its spots than typical when rotating towards the west limb, with some simplification likely. The remaining regions remained stable or decayed slightly.

No Earth-directed CMEs were observed in the last 24 hours, however there were events of interest. The C8.4 flare from AR3382/AR3383 resulted in a faint and weak CME, however this has been modelled as missing behind Earth. A very fast far-sided full halo eruption was then visible in SOHO C3 coronagraph imagery from 24/1800 UTC.

Solar Wind / Geomagnetic Activity: Observations by ACE/DSCOVR at L1, are indicative of a weak connection to the fast wind, most likely from coronal hole 27 on the northern disc. Solar wind speeds varied from background to slightly elevated at 350-450km/s. Density was below average. Interplanetary magnetic field (IMF), Bt, was weak and steady at 5-7 nT with north-south component variable and ranging from +6 to -6nT. Phi angle was predominantly negative (towards the Sun). Geomagnetic activity was Quiet to Unsettled (Kp 1-3).

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux rose after 24/1820 UTC in response to the large far-sided event. This peaked below the S1/Minor Radiation Storm threshold (10pfu) at 7.55pfu at 24/2055 UTC before very gradually and erratically easing thereafter. GOES16 high energy (greater than 2MeV) electron flux was Background to Moderate throughout, with the associated 24-hour integrated fluence persisting below the Active threshold. A slight rising trend was observed, with 7.96e6 total pfu at 25/0000 UTC

Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate activity is expected, with a chance of isolated M-class flares.

Solar Wind / Geomagnetic Activity: A CME from 23 Jul due to the C7 flare of AR3376 may give a glancing impact either later day 2 or early day 3 (26-27 Jul). Otherwise current weak fast wind conditions are expected to persist. A further weak coronal hole HSS may arrive later on day 3 (27 Jul) or day 4 (28 Jul) however this is low confidence. Mainly Quiet geomagnetic

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activity at first, with a chance of isolated Unsettled to Active intervals. This increasing to give a period Unsettled to Active, with a chance of G1 Minor storms with any CME arrival, either late day 2 or early day 3 (26-27 Jul) and a slight chance with any further HSS enhancement later day 3 or 4 (27-28 Jul).

Energetic Particles / Solar Radiation: The high energy (greater than 10MeV) proton flux is expected to continue declining towards background. Observed values may increase ahead of any CME arrival however, and there remains a slight chance of proton flux increasing from any further significant flares that occur. Radiation storms are currently not expected however. The high energy (greater than 2MeV) electron flux is expected to persist at mainly background levels, but with a chance of becoming more persistently moderate, perhaps rising to high once any CME influence recedes days 3-4 (27-28 Jul). Active fluence is currently not expected.

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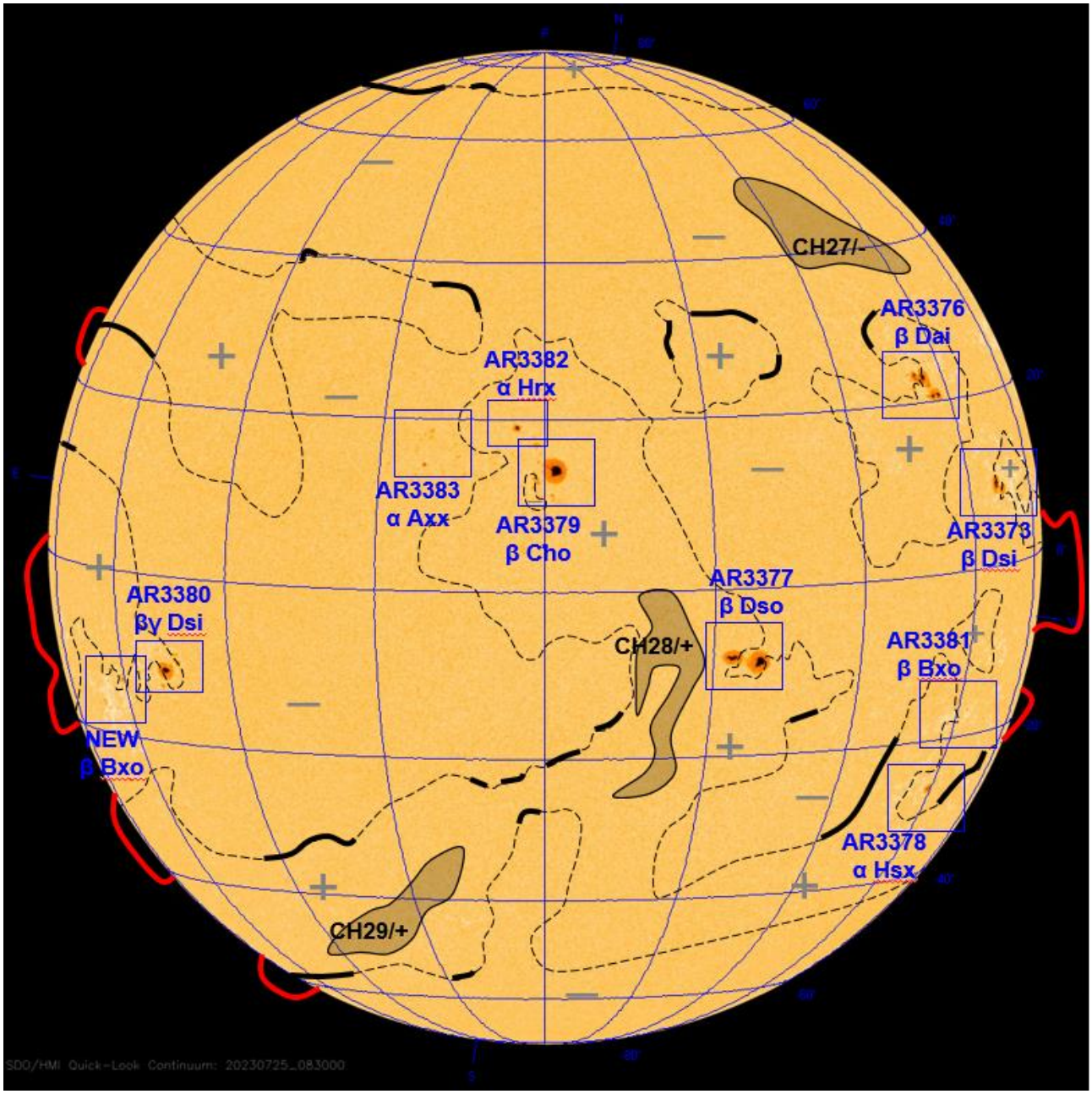
Figure 1. Solar Analysis Valid 25/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

The long period C7.4 flare from AR3376 at 23/1457 UTC produced a partial halo CME, which is forecast to give a likely glancing impact either later day 2 or early day 3 (26-27 Jul). This has some notable uncertainty on the arrival time, due it being a likely glancing impact and a coincident, and uncertain, coronal hole enhancement. There is also a broad shock from this CME, which may enhance conditions ahead of this arrival.

Otherwise current slightly elevated winds are expected to continue until any CME arrival, perhaps slowly easing, with Earth likely seeing a waning connection to the fast wind of CH27/- in the northern solar hemisphere. A further enhancement from any fast wind associated with CH28 is possible on day 3 or into day 4 (27-28 Jul), however this is low confidence given the small and indistinct nature of this feature and a more westward location compared to the previous rotation. Mainly Quiet geomagnetic activity at first, with a chance of isolated Unsettled to Active intervals. This increasing to give a period Unsettled to Active, with a chance of G1-Minor storms with any CME arrival, either late day 2 or early day 3 (26-27 Jul) and a slight chance with any further HSS enhancement later day 3 or 4 (27-28 Jul).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	10	30	30	10
Strong	G3	No	1	2	2	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
23/1915	Partial	Flare	NW AR3376	735 km/s	27/0001 UTC	Low confidence. Glancing impact expected.

Figure 2: Latest ENLIL Ensemble forecast showing wide range of solutions for the above CME. Also note slight peak in some members later on the 25th July associated with a low probability of a faint glancing blow from a previous CME.

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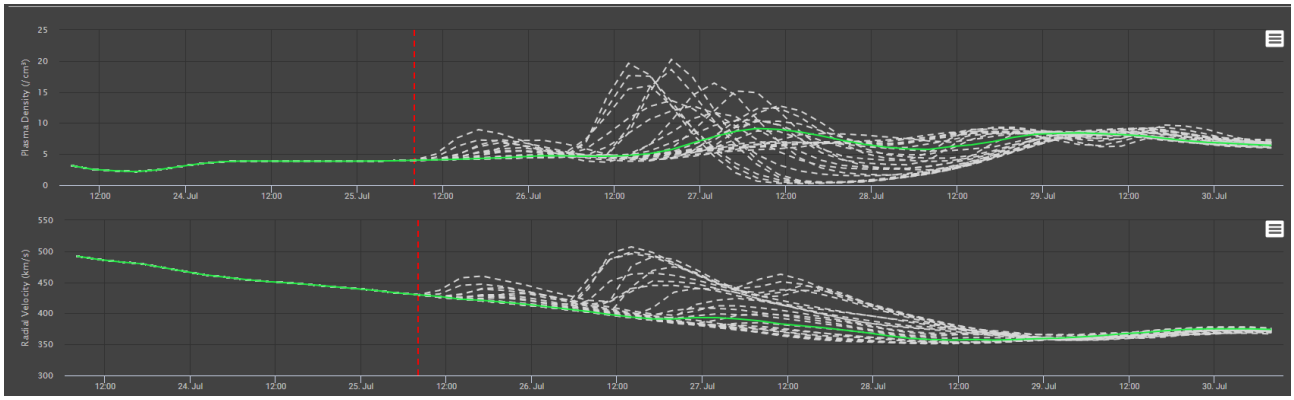

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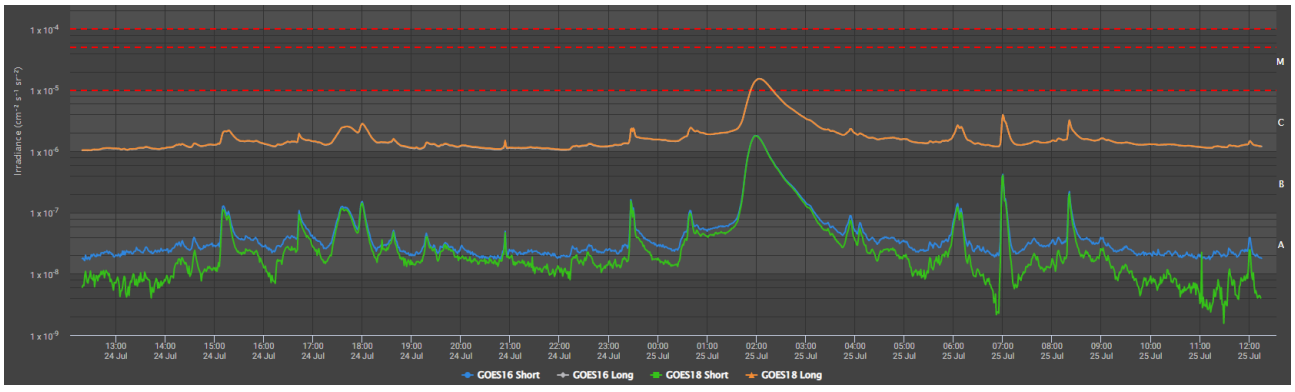
Radio Blackouts - X-Ray Flares:
Solar activity has been Moderate over the past 24 hours with a long period M1.5 flare observed from AR3376 peaking at 25/0203 UTC. Low to Moderate solar activity is expected, with an ongoing chance of isolated M-class flares.

AR3380 in the southeast and AR3376 in the northwest are potentially the most likely flare candidates, with ongoing slight growth in surrounding spots, and an east-west component to the polarity separation line in AR3376 suggesting increased potential instability. The AR3380 region dominated by a leader with moderately sized umbra, surrounded by a proliferation of smaller and less mature spots. The trailer is recorded as a separate region, but is likely within the same broad plage area resulting in a wide and complex area. This complexity is also indicated through significant looping evident in SDO imagery. AR3376 has also exhibited significant growth, with the recent emergence of a leader spot to the south of what was a mature unipolar region. Further development remains possible with this region. AR3373 is the other main flare candidate, however this is now hard to analyse as it approaches the western limb. What was the larger complex central northern disk continues to be split into three separate regions. The other regions are generally simpler, some moderately sized but appearing generally stable.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	50	50	40	30
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: Latest 24hr GOES-16/18 X-Ray flux



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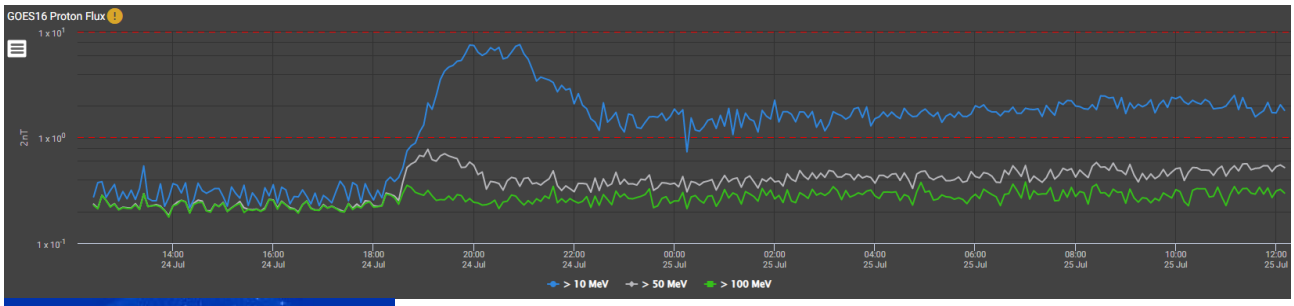
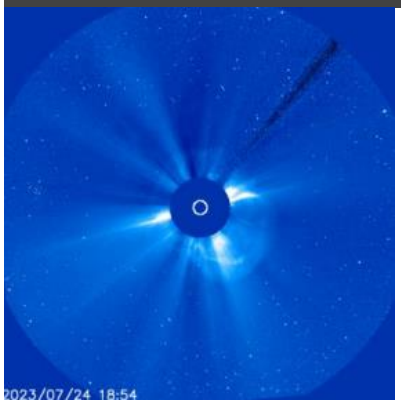
Solar Radiation Storms - (High Energy Protons):
The high energy (greater than 10MeV) proton flux observed by GOES16 became enhanced on 24 Jul due to a large far-sided eruption, from what was likely AR3363 which is now far around the western limb and approaching far-side centre disc. This increase peaked at 24/2255UTC just below the S1 threshold at 7.55 pfu before gradually easing. These above background proton levels are likely to only gradually and erratically ease towards background through the coming days, and some increase is possible day 2 (26 Jul) ahead of any CME arrival.
Further enhancement from the far side event considered unlikely, but cannot be completely ruled out on day 1 (26 Jul). There is also a potential for any significant flares from the regions on the visible disc to give a slight increase in observed values, with a slight chance of approaching the S1 threshold.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	20	10	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4:GOES-16 >10 MeV, >50 MeV and >100 MeV Proton Flux, and image of the far-sided CME from SOHO-C3.





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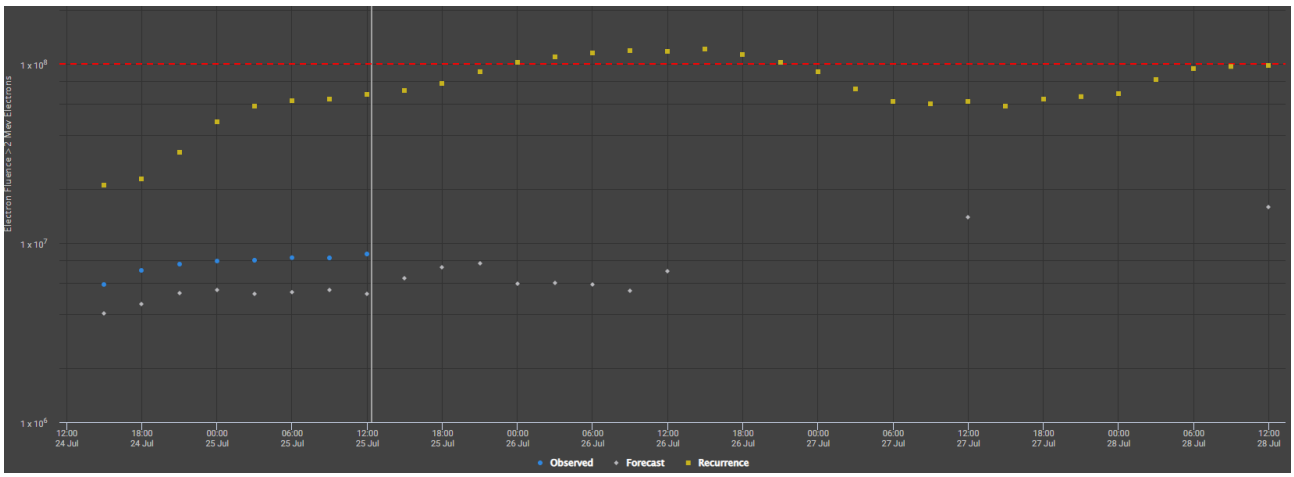
High Energy Electrons Event (≥ 2MeV):
High energy electrons (greater than 2MeV) are at Background to Moderate levels. No significant enhancements are currently expected, but values may recover to be more persistently Moderate, perhaps briefly High levels day 4 (28 Jul) depending upon any CME arrival either late day 2 or early day 3 (26-27 Jul), and how geoeffective any impact is. 24-hour electron fluence is most likely to remain below the Active (1e8 integrated pfu) threshold throughout the period, as indicated in MOSWOC REFM. A rising trend is likely later day 3 and through day 4, once any CME influence subsides, depending on the extent on any CME impact that occurs.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	1	1	1	10
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 5: Latest MOSWOC REFM model output



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